Npdgamma Collaboration Meeting – Sept. 28, 2002

(Stream of Consciousness notes from Shelley's laptop)

1. David – opening.

Focus of this meeting: How are we going to finish building things, validating the various components and integrating them into a real experiment?

Major political developments: still have not solved problem of B field from adjacent flight path acting on our apparatus.

Seppo/David have been working on it. It is a difficult magnetic shielding problem. The amount of steel we need could easily exceed the floor loading limit, which we can't do. We have made significant progress; now we have the support of Physics Division administrators. DOE won't give more money to the program until the problem is solved. The scope of the problem is about $400k. Los Alamos has told DOE they will find a solution, but nothing has really started to happen from the lab side.

(NB Fitzsimmons has built a bare, unshielded magnet, no return yoke, never mind the MOU – turned it on last week!)

Basic requirement: any change in B field resulting from the neighbor's magnet must be less than 10 milliGauss. Strategy: we will shield 1 Gauss from the neighbor's magnet as best we can. LANL has to fix the rest of it.

Experiment Review: Nov. 5, 6, 7 at LANL -- need work package managers to attend. Need a solution to the field problem before this meeting.

Question: (Tim) Could we run the experiment at 10x higher field? Answer: Systematics depend on relative effect. But it would not be trivial: RFSF, electronics, all would have to change. Big redesign of the experiment would be required.

2. Seppo – Status of Project, DOE Review, Funding

Management aspects – mode of the experiment is changing from design to testing and integration.

Sending timelines every month to DOE. Example from May 02. Beamline almost complete; construction 29% complete (60% expected). Almost all the DOE funds for npdgamma have already been released to LANL.

Milestones are more significant than % finished etc. We are not meeting enough milestones. Chopper and guide are about a year late. DOE asks why? Complicated situation. Guide company was late, etc.

Biggest problem now: Cave was supposed to be ready 11/02. Not even designed. Asking DOE for a new baseline. DOE has not given us a very hard time yet. Jehanne is sympathetic to npdgamma, but she is worried. Schedule is very tight for the rest of the project, dominated by the readiness of the cave.

Cave: work package includes tunnel and the cave. At the moment we are $200k over budget compared to the numbers Seppo shows to DOE, due to shielding requirements (but not solved yet).

Comment (Roger) – if you have to fix the cave, you need to spend $1M between now and next spring. Very aggressive schedule. Hard to spend money that fast. Reviewers will question it. This will put a lot of pressure on LANL to fix it. David – what's holding it up is the lack of decision making by LANL.

Other items – 3He, target, utilities, still have a long way to go. DOE is concerned about our spending rate being consistently low.

Reporting: Next report to DOE Oct 11 – this will be input to the review. For review, we need to send a 10-15 page summary by Oct 18. Need 1 page from each work package manager covering status, plans, commisioning, experimental program, layout of operational plans as input to the review.

Beamline: Overall pretty well on track. Lots of photos, etc. Right now, ER1 is not accessible, since the beam is on. All work is on the ER2 side. Next week, starting on shielding, tunnel in ER2.

(NB field at center of our cave location from bare magnet with partial shielding next door is 0.7 Gauss at beam height. Field along the wall at floor level is 40 Gauss. We need .01 Gauss max from their magnet.)

(Comment – Tim – effect on unpolarized beam upstream of cave due to Stern Gerlach? dBy/dx. David - will separate the spin states but not affect npdgamma.)

Last 12 m of guide – installation starts mid Feb 03. Manufacturer is on track. Steel vacuum jacket. Problem: Guide Sag? Can't put a post inside the cave. Has to be cantilevered. Calculated how much it would sag. Tolerable.

Temporary Cave: for test measurements late 02. Measure moderator brightness, test shutter, ER1 part of guide. If we don't do it in a temporary cave, we have to do it in the real cave in an engineering run. LANSCE division would like us to do this.

Schedule: beam off Feb through end of May. Chopper in, mid Feb. Guide install Feb-Mar.

3. Chopper – Mark

Everything is at LANL except final rotors, which were delayed in coating process. Balancing etc. took some time. Test rotor balanced last week (uncoated). Phase lock achieved with fully assembled system. (Full speed) Shutter speed about 1.5 ms (full open – full closed). (99% attenuation of neutrons for E< 100meV -> 1 lb Gd.)

Control system will sit on ER2 side. (If t0 drops out, the rotor will spin down gracefully and wait. Spin up time about 1 min. – controls can be programmed. Currently in second iteration of control system – now using Lujan center standard controls. Velocity and phase controller had to be replaced by one that was tried and tested in another beamline.)

Lots of phase jitter from t0's – it will jump by up to 20 microsec. Have to make a correction or the chopper would get totally out of phase in a short time. Send a veto signal to the electronics depending on phase jitter for bad pulses. ($2x10^{-4}$ meV/microsecond slope for time offset.) (NB 100 microsec jitter is small compared to 1.5 ms closing time for the shutter)

Remaining schedule: Oct/Nov 02 test coating samples, balance coated rotors. Install Feb 03

Remaining issues: motor water cooling? (not using now, they don't get hot) Shift to VME controller? ($7k) Currently using borrowed system. Mark recommends we buy our own.

4. Commissioning and Cave issues – David

Strawman order and schedule. Assume cave ready 04/03. Have to iterate this for the review. Times not necessarily realistic.

Beam tests in cave	**0.5 week starting April 03**
Install, test, remove target	**2 weeks**
10 G magnet, 2x3He, monitors, RFSF efficiency,DAQ	**2 + 1 weeks**
Install CsI and electronics	**1 week**
Rates, shielding, alignment, Cd expt	**2 weeks**
Remove magnet, reinstall LH target	**1 week**
Install 10 G magnet, tune up for data	**2 weeks**
Begin data taking	**Aug 03 – Dec 03 (4 months beam off)**

For DOE review. Need report to committee by Oct 22, by each WP manager: Role in expt., discuss approach, milestones achieve, future, schedule for tests and commissioning, plan for operating and maintaining each system.

Plan for operating the expt. Program and shift requirements. Working hypothesis: we are going to know the result from each run soon after the run is completed.

Magnetic shielding. Systematics < 1/10 statistics, same goal as for other systematics. Either solve the problem $\Delta B < 0.01$ G with passive shielding (requires 1/70 reduction) or propose to LANSCE

that we build the best shield for $200k that does not exceed the floor loading limit and LANSCE be responsible for shielding FP11 to a level where we can operate.

Discussion – they can actually solve the shielding by 04 so long as we get the clear running in 03 with Fitzsimmons turned off. We are aiming for a 20% measurement of f_p in the first run. Then they can actually implement their solution in 04. Would this work?

We need to sleep on David's strawman model and come back with suggestions tomorrow morning in the discussion at 9:30

5. Magnetic shielding problem – Seppo

Simple model – double shell shielding. Proposed structure: 2" steel, 2" poly, 2" steel. Inside and outside a 1" thick layer of 5% boron loaded poly. (total thickness 8", floor would be 7", top layer is 1" poly). Applied field 0.7 Gauss from FP11. 10 Gauss internal field in our cave. David has an analytical model for concentric spheres, plus numerical modelling at LANL.

Sample result: 1 cm A-36 steel shielding only takes the field down from 1.3 to 0.7 Gauss at the center of cave (z=0 on plots). Why? (We need a factor of 1/70, not a factor of ½!) Permeability is a function of field! Since imposed field is different at different locations, numerical calculations are not so reliable. At applied field of only 1.3 G, permeability is very small, so the shielding is dramatically less effective.

David's model shows you don't win by making layers for a given amount of shielding if the permeability is constant. The reason for layers is because of the field dependence of the permeability.

Bottom line: this type of shielding will not be sufficient to shield the FP11 magnet by a factor of 70. Strawman design gives factor 4 or 5 shielding. Shielding factor is S1 + S2 + c*(S1*S2). Don't know the multiplicative factor c. Have to build a prototype to calibrate it. (This is a subtle problem -- most field experts don't understand it. Numerical programs tend not to allow for μ to be a function of field.)

Availability of steel for cave? In any case we have to order it from a factory. Tight schedule but Seppo thinks it can be obtained according to the schedule that he has shown.

6. Guide Field – Roger

Last of the 4 field coils is being delivered. Main power supply delivered and tested at UCB. Other items in hand or have been ordered. Tom Case will start constructing the stand when he returns. Don't see a problem with system being delivered to LANL March 1, 2003. Coil frame is very strong – structural member in its own right. Adjustable connection to a few turns in each coil – aim is to have minimum current in the external correction coils.

Strawman schedule would prefer to install field coils only once. LH2 target – in/out through the door? Roger would prefer to see a "linear" installation schedule with branch points to

accommodate delays. Removing things incurs some risk as well as time required to reinstall. If successful, you get more time at the end for physics.

Discussion – should put the coils in first of all, because the amount of roof that removes is only a panel for the CsI etc.

Need explicit and detailed installation and alignment plan for each item. Discussion – 3He people need to scan the field by a few Gauss for calibration purposes. (Should be ok.)

Information about field strength and coil currents will be available for DAQ. Issue: anything needed for analysis of experiment should be in the main data stream, not in some parallel scheme that has to be correlated later. Use DAQ for monitoring, but not controls. (Scott/Greg in charge)

Fluxgate magnetometers preferred over Hall probes. Change to dc field is minimal due to m metal in the measuring device. NB will put power supplies for magnet inside the cave.

Questions: is there a shimming procedure worked out once everything is in place? Tom Case is in the process of working this out. What if there are nonuniformities along the beam direction? Can put up shim coils along the sides, have enough supplies to do this. What if the steel turns out to be magnetized? Etc…

Issue – 2.5 cm tube of electronics in a gap between the CsI and the hydrogen target? m metal content. (resolve offline) Need feedback on as built dimensions to Tom Ries.

7. Target – Mike Snow (transparencies by hand)

About one month behind original schedule. March 2003 before it gets to LANL. Will be assembled leak and pressure tested, cooled, operated with PLC control, accident scenarios simulated, etc with H2 in GHS prior to shipping to LANL.

Changes since last collaboration meeting:

- **Titanium target vessel**
- **He gas channels instead of double-wall (great simplification)**
- **Target design integrated with detector and stand**
- **Operate target at 1.25 bar**

Status: contracts awarded, cutting metal. Responses to safety committee complete except for final gas handling system (in progress)

Advantages of Ti vessel: (Note, major disadvantage subsequently realized – huge n capture cross section! We are going back to an aluminum vessel as of Nov. 2002)

- **Stronger than Mg/Al – machined main flask out of a solid piece of titanium**
- **No mg/Al seal required**
- **Neutron shielding now on outside of target vessel -> AMSE approved (used in NASA LH2 rockets)**

Delay with respect to original schedule mainly due to change of main vacuum vessel design, interaction with vendor and safety committee. Eliminated a number of internal welds by making main vertical box out of a single piece of Al. (40% heavier than originally.)

Discussion: Required to surround welds and o-ring joints by He gas. But He diffuses through o-rings? Suggestion of metal o-rings, as used at Jlab. Need clear procedures for target operation – safety issue. Training of operators etc. Trying for design that the worst case is just the target venting up the stack.

Question – does it need 24 hr monitoring? Not when it is in a stable situation, but we need someone on call. Need monitoring when it is liquefying etc.

Discussion (Roger) -- Uninterruptable power supply? Should have it so the control system doesn't go out. Discussion – no UPS planned? Interface with Scott. (NB vacuum sealed off, not required to be pumped.)

Also – ballast in system? Experience at Jlab shows this is really important. Small fluctuations need to be damped out or the target will just vent all the time. Al gas cylinder hooked up outside? Hard to sell to safety committee? …

Note – one more operational review to go for the target. Procedures etc can be reviewed at that time.

8. ^{3}He system – Kevin

Schedule overview:

- **Full test of polarizer at Michigan in November 2002**
- **LANL laser lab testing January –Feb 2003**
- **Cave installation and testing – April 2003 (2-3 weeks overall)**
  - **AFP, laser, heater systems**
  - **Cell lifetime (500 hrs = 3 weeks 1/e time: check of field system!)**
  - **High polarization check**

Oven – heater control outside, but booster heater inside cave. (Todd Smith) Windows are 6" silicon wafer for neutrons. Nice photos of heater and cell system – need drawings to Seppo.
Need compressed air system for heaters. 1 kW hot air in cave – air exchange? Need to be careful, don't want oil from air compressor spewing onto the windows.
Issue – collimators – where will they be put? Mounted on the face plates? Best location is near the cell. Could use boron carbide, it would take the heat better than lithium plastic.

NMR - all systems procured, at Hamilton. Data systems on windows laptop.

Lasers – behind on procurement, but all essentially at Michigan, arrived last week. Still missing lenses from LANL

Heater/controller – testing at U Dayton

Mechanical support – design essentially ready. Check with integration. Purchase list to Seppo.

New cell: `Kirk' at NIST. 10 cm diameter, 7 cm long, T1=500 hrs
(Current inventory: 2 x 11-cm cells, plus 2 x 10-cm cells)

Narrowed lasers are looking nice but not at a stage to purchase them yet.

Issue: We need a small group to specify the shielding and collimation, where to put it, how to mount it, etc. interface with instrumentation groups.

Polarizer issues:

- **How often do we flip and do AFP polarimetry?**
- **Manual/remote optics?**
- **B-sweep during commissioning – interaction with Roger/Tom C**
- **What is needed for laser safety?**
- **How much room outside the cave?**
- **Alignment and neutron collimation.**

9. Analyzer – Bill

Discussion – how good a measurement do we really need? Analyzing power of filter = polarization of transmitted beam if it is unpolarized to start with. General feeling is to use it at the beginning and tune up the RFSF. (May need to test it quite a number of times. Need it to be reliable and robust.) How thick and how highly polarized does the analyzer need to be?

Recommend a state of the art cell. Assessment Oct. 14 at LANL. Grad student is working apparatus for polarizing an analyzer at UNH.

Need:

- **Polarizing station**
- **Polarization measurement**
- **Transport case**
- **Cells Beamline fixture**
- **Beamline aperture**

Discussion. Need to demonstrate that we understand the RFSF at the 1% level. Demonstrate that the beam that goes through the LH2 target is polarized. (what size should the cells be? Maybe 2" in diameter. Why not use a spin flipper cell? - those are fairly thin.)

Priority should be first to get something working, then see if it can be improved on. If the cell is small, need to move it around to scan the acceptance.

10. RFSF Discussion – Scott et al.

Issue – vulnerable to drifts in the RFSF. Need to check with analyzer cell. Monitor carefully. Do we understand the spin flip efficiency as you go off axis? Build this into commissioning plan, then check with on-axis efficiently. Need to write up a commissioning plan before the DOE review.

11. Detector Tests at LANL – Michael

All detectors have been tested with gamma sources and are at Los Alamos:

- **^{137}Cs and ^{241}Am spectra peak widths**
- **5" S-20 PMT at 1.6 kV**
- **Computer interfaced MCA**

Obtain number of pe from statistical fluctuations assuming 1/sqrt(N) + independent "intrinsic contribution" that is energy independent, from the crystal. Fit expression for width-squared to 1/E. Errors from least squares fit to graph. Results for 48 det. Avg 1292 pe/MeV with a full spread of about 300 pe/MeV (40%). Not a Gaussian distribution over the 48 dets. Need optical coupling grease, gives a factor of 2 increase in signal over no coupling. Windows are not smooth. 3 detectors have non-protruding/slanted windows (one of them critical – they are supposed to protrude by about 1/50") Worst one has to be sent back (all 3?)

Schedule:

- **VPD efficiency measurements (Japan, underway)**
- **CsI VPD matching at LANL**
- **Check VPD's with a common LED**
- **Collect hardware to mount preamps**
- **Feedback resistors arrive in November**
- **Assembly of preamps**
- **Testing with DAQ**
- **Gain temperature dependence test**

Question – what about crystal intrinsic resolutions? The ones with very low pe/MeV also have large intrinsic resolution. Suggestion – turn crystals sideways, see if one half is bad?

Discussion – where is our assembly area, counting house etc? LANSCE promised it. David has to pounce on them. Ready to install on stand whenever it arrives.

12. VPD Tests – Magnetic Fields (Greg & Seppo)

Work done by summer students this summer. Realize that the second derivative d^2G/dB^2 is what we are sensitive to (first derivative cancels. Previous measurements of the first order effect were of order 10^{-5}/Gauss.

New data: first order term is $2x10^{-5}$/Gauss; second order term is $1x10^{-5}$ /Gauss^2

Implications: 10^{-10} effect on asymmetry gives requirement that RF leakage from spin flipper must be less than a few milligauss at the detectors. This should not be a problem. (Note: there is a cancelling effect in taking ratios of detectors, which makes us even less sensitive.)

Masuda has done first beam test with VPD's. Beam brought to Cd and In targets. Old CsI with VPD connected to it. In gives 2 resonances; Cd gives thermal. Finds factors of 2.5 difference in the 3 VPD's he has tested so far. Ready by November!

13. Detector stand – Tom Ries

Plan is to keep machine shops busy, get the stand ready by November. End plates in TRIUMF shops, ready in about 2 weeks.

Accommodate the floor height adjustment by making the lower half of the stand bolted together, not welded – make it last, and can cut plates if we have to adjust. Drawings for base part go into shops next week.

Action – updated sketch with dimensions – send to Greg for posting on npdgamma web site. Should put some extra holes to attach handles for assembly of the heavy 4 and 8 packs.

14. Electronics – Scott

Scott has a draft of a writeup on the electronics. Basic preamp design has not changed much. Gain is 50 M-Ohm in the I-V and x2 in the second stage for an effective 100 M-Ohm.

Lots of time spent on noise. All dominated by the design of the first stage. Sources are op amp current and voltage noise, and Johnson noise in feed back resistor (largest contribution). Naïve estimate about 18 fA/sqrt(Hz). Expect shot noise in signal to be 5 pA/sqrt(Hz), dominating over the electronics. "Spice model" found broad noise peak (intrinsic to the op amp) at about 50 kHz – even with filtering can substantially increase the noise seen in the preamp -> go to a steeper filter. Compare to actual measurements. Qualitatively in agreement but measurements show about a factor of 2 more noise. After filtering (6 pole Bessel filter), very good agreement with spice model, and noise is reduced about a factor of 10. Step response: 6 microsec rise time. Much faster than we need. 100 microsec rise time with filter; still ok.

Status: photo of final prototype. All parts ready for assembly except the circuit boards. Also waiting for feedback resistor. 11 week delivery, expected in November. Technician is contracted to assemble boards, with everything but the fb resistor. Preamp housings exist.

Next stage: just approved board layout for sum and difference amp.

15. DAQ – Greg

Three VME-crate system: VME1 outside the cave for proton current etc., others inside. Inside: fast sampling ADC's, VME2 used only for detector difference signals.

Each crate has its own cpu running linux. Fiber optic ethernet between crates. Well along but still have some minor issues with timing and control. Should be able to take data with all 48 detectors once we have the preamps etc in December.

Data storage: total data will about about 20 T-bytes. DLT tapes. RAID array? DVD's? 4 GB each – will be available "next month"… useful experience at Bates – cheaper storage?

Outstanding issues:

- **Finalize communication between crates**
- **Software – online and offline analysis (need a lot of work)**
- **Data storage solution**
- **Unknown needs and requirements.**

16. Precision Polarimetry – Tim

Proposal to use npdgamma beamline to develop precision polarimetry of pulsed cold neutron beams. NB spin flipper is really a spin rotator.

Spin asymmetry is APz (1-cosq) / (2 + A Pz (1 + cosq)) Need to know Pz(l) and q(l). How accurately can one do this? (Aim: significantly better than 0.1%) Motivation: A coefficient in neutron beta decay. 0.1% is much better than we need for npdgamma. Ratio of 3He transmission for 0 and 60% polarization of 3He gives absolute polarization measurement as a function of neutron wavelength. Relies on assuming that the absorption cross section is 1/v. Don't know that better than 0.1%. Experiment with no spin flipper. Bowman et al did it to 0.3%. Landau paper discusses 1/v cross section; Westcott et al nuclear engineers have a treatment of this to 10^{-4}. Need an analyzer. For completely opaque analyzer, you can make the analyzing power arbitrarily close to 1. Comment – Scott – have to worry that the acceptance is known. Also detector background. Tim wants to make a small cell but opaque and scan it around. Problem with knowing collimation etc. This is much more than we need to know for npdgamma. Claim, can get statistics better than 10^{-3} in a 1 hr measurement. Want to use npdgamma beamline for about 2 weeks to push transmission measurement to the limit. Discussion. Systematics is really the issue. David is concerned that the cave is not really optimized for this measurement. Lots of neutrons flying all over the place.